Chapter 71
Methods for Simultaneous Improvement of Comb Pass Band and Folding Bands

Gordana Jovanovic Dolecek
Institute INAOE Puebla, Mexico

ABSTRACT

This decimation introduces the replicas of the main signal spectrum. If the signal is not properly filtered, the overlapping of the repeated replicas of the original spectrum, called aliasing, may occur. The aliasing may destroy the useful information of the decimated signal and must be eliminated by the filter which precedes the decimation, called decimation filter. The most popular decimation filter is a comb filter, usually used in the first stage of decimation. However, its magnitude characteristic is not flat in the pass band of interest and there is not enough attenuation in the folding bands. Different methods are proposed to improve comb magnitude characteristic. This chapter presents an overview of methods for simultaneous improvement of comb magnitude characteristic in both: pass band and folding bands. The methods are divided into three main groups: sharpening-based methods, corrector-based methods, and methods based on the combination of alias rejection and compensator design methods.

INTRODUCTION

Decimation is a reduction of a sampling rate in a digital form by an integer, called decimation factor. It consists of two stages: filtering and down sampling. Practically the sampling rate is decreased only in the second stage, called down sampling (Harris, 2004). However, during this process, the replicas of the main signal spectrum occur. If the signal is not properly filtered before down sampling, the overlapping of the repeated replicas of the original spectrum, called aliasing, may occur. The aliasing may destroy the useful information of the decimated signal and must be eliminated by the filter which proceeds the down sampling, called decimation filter.

The most simple decimation filter is a comb filter which has all coefficients equal to unity, and consequently does not require multipliers, (Hogenauer, 1981). The transfer function of comb is given as:

DOI: 10.4018/978-1-5225-7598-6.ch071

$$H(z) = \left[\frac{1}{M} \sum_{k=0}^{M-1} z^{-k} \right]^K, \quad (1)$$

where M is the decimation factor, and K is order of the filter.

Note that all filter coefficients are equal to unity. The comb transfer function (1) is also known as non recursive form. An equivalent transfer function, also known as a recursive form, is given as:

$$H(z) = \left[\frac{1}{M} \frac{1 - z^{-M}}{1 - z^{-1}} \right]^K. \quad (2)$$

From the recursive form (2), a simple comb structure, called CIC (Cascaded–Integrator-Comb) filter, proposed by (Hogenauer, 1981), is obtained. It consists of the cascade of K integrators $1 / (1 - z^{-1})$ and K combs, $(1 - z^{-1})$ separated by a down sampler by M.

To preserve the decimated signal, the comb magnitude characteristic:

$$H(e^{j\omega}) = \left[\frac{1}{M} \frac{\sin(\omega M / 2)}{\sin(\omega / 2)} \right]^K, \quad (3)$$

must have a flat magnitude response in the pass band of interest, and high attenuation across the bands around the comb zeros, also called folding bands. However, comb magnitude characteristic exhibits a low attenuation in folding bands and a pass band droop in the pass band of interest, which may deteriorate the decimated signal. Increasing the order K, the attenuation in folding bands is improved, as shown in Figure 1, for M=9 and K=1, 2, 3, 4, and 5.

However, the pass band droop is increased as illustrated in Figure 2, for the same parameters as in Figure 1.

Different methods are proposed for decreasing comb pass band droop, increasing the attenuation in the comb folding bands, and for both: simultaneous decreasing of comb pass band droop, and increasing folding band attenuation. The goal of this article is to present the principal approaches for the comb simultaneous pass band and stop band improvements.

BACKGROUND

First, the comb pass band and folding bands are defined. Comb pass band is determined by the pass band edge ω_p, which depends on the comb decimation factor M and the decimation factor R of the stage which follows the comb decimation stage (Kwentus & Willson, 1997):

$$\omega_p = \frac{\pi}{MR}. \quad (4)$$

Related Content